JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. 11 OCTOBER 4, 1921 NO. 16

PHYSICS.—*A radioactive quantity requiring a name.*[1] N. ERNEST DORSEY, Bureau of Standards.

The problems that are encountered in the quantitative study of radioactive materials and processes may be divided into two classes. In one class will be placed the strictly chemical problems; such as, the amount of the element that is contained in a ton of ore, the ratio of the amounts of different elements that are found associated, the atomic weights and the chemical properties of the several elements. In the other class will be placed the problems that are primarily concerned with radioactive phenomena; such as, the rate of transformation, the rate of emission of energy, the rate of production of alpha or of beta particles or of gamma pulses.

In problems of the first class one is concerned with the total weight or with the total number of atoms present, and the amount of the element may appropriately be expressed in grams or in terms of the number (N) of atoms present. These problems do not differ in any essential respect from those encountered in dealing with other elements; the radioactive properties of the element enter into the problem mainly as a means by which different amounts of the material can be compared.

In problems of the second class the results may likewise be expressed as functions of the total weight, or of the total number of atoms, of the element present, but when this is done certain fundamental relations are obscured. Only a relatively small fraction (λN) of the atoms present take part in the phenomenon studied, and the thing that is of fundamental interest is the effect produced per atom actively concerned. It is in this effect per active atom that information regarding the atomic forces, structure, and instability, and the way these vary from element to element, are to be sought. In such problems one is concerned with the number of atoms that have transformed in a certain time; he is but incidentally interested in the presence of atoms that have remained untransformed. He wishes to know

[1] Contribution from the Bureau of Standards. Received August 1, 1921.

the energy emitted per transformed atom, the number of alpha particles emitted per transformed atom, etc. If his observations extend over a time t, he wishes to know the number of atoms transformed during that time; *i.e.*, λNt where λ is the transformation constant, and N is the total number of atoms present. He is primarily interested in λN, rather than N.

When only a single element is being considered it is a matter of indifference whether the result is expressed in terms of grams, or of N, or of λN. But when similar measurements have been made for two different elements, and it is desired to compare the results obtained these must each be expressed in terms of the quantity, λN, involved, if fundamental relations are to be obtained. For example, if it is desired to compare the heating effect produced by the transformation of radium with that produced by the transformation of radium emanation, then these effects are expressed in gram calories per hour per gram of radium, and per that amount of radium emanation that can exist in equilibrium with one gram of radium; λN is the same for each of these quantities. This is quite satisfactory when only related elements in an unbranched portion of a family are being considered; but if a lateral branch arises between the first and the second element, then a more complicated description of the reference amount of the second element is required. For example, uranium-II branches into uranium-Y and ionium, some 4 per cent going into the former; consequently the heating effect of one gram of uranium-II is not strictly comparable with the heating effect of the amount of ionium that can exist in equilibrium with one gram of uranium-II, but with $1/0.96$ of the latter amount.

When the effects of elements belonging to unrelated families are to be compared, they will likewise be referred to quantities having the same value for λN; *i.e.*, to quantities so chosen that the same number of atoms take part in the production of the effect. For one element the result may be expressed in terms of the effect per gram, but the corresponding quantity of the other element cannot be very directly expressed with our existing terminology.

This difficulty would be removed if there were a name to denote the amount of a radio-element corresponding to a fixed value of λN. For example, if λN for one gram of radium is equal to k, and that amount of any element for which $\lambda N = k$ is called an r, then an r of any element will be radioactively comparable in amount to an r of any other element, whether related or not. A gram of radium will contain one r of radium, a curie will contain one r of radium emanation,

the amount of radium-A that can exist in equilibrium with one gram of radium will contain one *r* of radium-A, the amount of ionium that can exist in equilibrium with one gram of radium will contain one *r* of ionium, the amount of uranium-II that can exist in equilibrium with one gram of radium will contain (1/0.96) *r* of uranium-II, etc.

As thus defined, an *r* of any material is *that amount of the material that will produce transformed atoms at the same rate as transformed atoms are produced by one gram of radium.*

The value in grams or in atoms of an *r* of any element depends upon the ratio of the transformation constant and of the atomic weight of the element to those of radium; denoting the transformation constant of radium by λ_0, the number of atoms in one gram of radium by N_0 and the atomic weight of radium by A_0 the number of atoms (N) in one *r* of any other element is determined by the equation

$$N = \frac{\lambda_0}{\lambda} N_0$$

and the weight in grams of one *r* of the element is

$$NA = \frac{\lambda_0}{\lambda} \frac{A}{A_0}$$

since $N_0 A_0$ is by definition equal to one gram.

To the precision with which the transformation constants are known, an *r* of radium emanation weighs 6.55×10^{-6} gram; of radium-A, 3.54×10^{-9} gram; of uranium-II, 1.51×10^{3} gram; of actinium, 1.29×10^{-2} gram; of mesothorium-1, 4.29×10^{-3} gram.

The quantity that we have denoted by the letter *r* plays in radioactivity a part that is analogous to that played by the gram-molecule in physical chemistry; the adoption of some name for it will appreciably facilitate the recording, discussion, and presentation of radioactive observations and phenomena.

One illustration of the increased facility that will be secured by the adoption of a name for this quantity is afforded by the frequent use of expressions of the form "radium-C corresponding to one gram of radium" (Rutherford), "von der mit 1 g. Ra in Gleichgewicht stehenden Ra-C Menge" (Hess); these would be replaced by the much simpler "one *r* of radium-C," where the letter *r* stands for the name adopted.

Another illustration may be taken from the surgical application of the active deposit of radium. When it is desired to state the amount of, say, radium-C present, a circumlocution like those in the preceding paragraph is required. This long and awkward expression is fre-

quently abbreviated to the form "x mg. of radium-C," or to "x millicuries of radium-C." Such abbreviations may lead to serious misunderstanding and confusion, and can readily be replaced by the exact and unambiguous expression "x mr of radium-C," so soon as a name has been given to the quantity r.

The customary expression for the rate of accumulation of a radioelement is

$$\frac{dN_2}{dt} = \lambda_1 N_2 - \lambda_2 N_2$$

where N_1 and N_2 denote, respectively, the total number of atoms of two successive elements. The rate of accumulation of element 2 is made to depend upon both λ_1 and λ_2, although it is evident that the instantaneous growth of element 2 can ultimately depend upon only its own constant and its departure from equilibrium. This is brought out plainly when quantities of the elements are measured in terms of r. Let there be R_1 r's of element 1 and R_2 r's of element 2; as before, let k denote the number of transformed atoms produced in unit time by one gram of radium; *i.e.*, by one r. Then kR_2 will be the number of atoms of element 2 that transforms in a unit of time, hence $kR_2 = \lambda_2 N_2$, where N_2 is the number of atoms of element 2. Whence

$$\frac{dN_2}{dt} = \frac{k}{\lambda_2} \cdot \frac{dR_2}{dt}$$

But

$$\frac{dN_2}{dt} = k(R_1 - R_2)$$

Hence

$$\frac{dR_2}{dt} = \lambda_2 (R_1 - R_2)$$

If $R_1 = R_2$ the two elements are in equilibrium. The differential equation shows at once that the instantaneous growth of element 2 is equal to the product of λ_2 by the departure from equilibrium.

The coefficients in the equation applying to the decay of a group of elements initially in equilibrium (Case 2 of Rutherford) are unsymmetrical when the equations are written in the usual notation, the total number of atoms present being the unit. For example, the coefficients for the third element (Rutherford's R) are

$$a = \frac{\lambda_2}{(\lambda_2 - \lambda_1)(\lambda_3 - \lambda_1)}; \quad b = \frac{\lambda_1}{(\lambda_1 - \lambda_2)(\lambda_3 - \lambda_2)}; \quad c = \frac{\lambda_1 \lambda_2}{\lambda_3 (\lambda_1 - \lambda_3)(\lambda_2 - \lambda_3)}.$$

When the unit is the r these coefficients become

$$a = \frac{\lambda_2\lambda_3}{(\lambda_2-\lambda_1)(\lambda_3-\lambda_1)}; \quad b = \frac{\lambda_3\lambda_1}{(\lambda_1-\lambda_2)(\lambda_3-\lambda_2)}; \quad c = \frac{\lambda_1\lambda_2}{(\lambda_1-\lambda_3)(\lambda_2-\lambda_3)}.$$

In these the symmetry is perfect.

A name for the quantity r would be most useful when curves similar to those given by Rutherford as figures 102, 103, 110 (*Radioactive substances and their radiations*) have to be plotted. The ordinates of these curves are proportional to the number of r's of the several elements, and to the sum of these r's. If the alpha particles from each element are equally effective in producing the effect measured, the total effect is proportional to the sum of the r's and on this assumption the ordinates are proportional to the "activities." In lieu of a name for the quantity r the ordinates are labeled "activities," and the assumption is explained in the text. Were there a name for the quantity r the ordinates could be so marked and no assumption would be required.

It has been shown how the weight of an r of any element can be computed. Consequently there is no serious difficulty in determining the number of r's contained in a given amount specified in grams; or conversely. In the portion of the radium family comprised between ionium and radium-C, both inclusive, the elements are now actually measured in terms of r, which in this region may be regarded as merely an abbreviation of the oft recurrent phrase "amount that is in equilibrium with one gram of radium." Beyond these branch points a factor depending upon the branching ratio must be introduced. Several methods are available for determining the value in r's of a radioactively defined amount of an element of another family. If a chemically pure salt of known composition either of this element or of another genetically related to it and not separated from it by a branch point has been prepared, we can determine at once the value of λN for a gram of that element. The ratio of this to k will be the number of r's in a gram of that element, and likewise in such amounts of its derivatives as can exist in equilibrium with a gram of it. Or the number of alpha particles emitted per second by the material considered or by an equilibrium amount of a related element might be determined. This number divided by 3.72×10^{10} (the value for one gram of radium, *i.e.*, the quantity we have denoted by k) will be the number of r's in the quantity considered, unless more than one alpha particle is emitted during a single transformation of an atom; this can be determined by suitable observations.

For many reasons it is desirable to have a name for the quantity which we have designated by the letter *r*. Thus arises the question whether the term "curie," which by international agreement is an *r* of radium emanation, shall be redefined so as to cover the entire field embraced by our definition of the quantity *r*, or whether a new name shall be added to the nomenclature of the science. In the latter case the name *rutherford* seems most appropriate.

In order to obtain an expression of opinion regarding the advisability of adopting a new name for the quantity we have denoted by the letter *r*, the Bureau of Standards submitted the preceding portion of this paper, in essentially its present form, to a number of chemists and physicists. While agreeing that it is desirable to have a name for the quantity *r*, the replies were divided regarding the advisability of adding a new name to the nomenclature. The majority of the replies favored the extension of the "curie" to cover the entire field, so as to avoid the existence of two names to denote the same amount of radium emanation.

Such an extension involves a redefinition of the curie. The extended term cannot be defined as the amount of an element that is in equilibrium with a known amount of any other element, though for the elements of the uranium family from ionium to radium-C it will actually denote the amount of these elements that can exist in equilibrium with one gram of radium. Neither should it be thought of as that amount of an element that under certain conditions will give a fixed, specified ionization current. Its definition must be equivalent to the one we have given for *r;* namely, as thus extended, a curie of any material will be that amount of the material that will produce transformed atoms at the same rate as transformed atoms are produced by one gram of radium.

MINERALOGY.—*Lazulite of Graves Mountain, Georgia, with notes on other occurrences in the United States.*[1] THOMAS L. WATSON, University of Virginia.

Graves Mountain, Georgia, is located in Lincoln County about 10 miles west from Washington, Wilkes County, the nearest railroad point. The locality has long been known to mineralogists for the occurrence of rutile and lazulite in association with a group of more common minerals. These are, named without regard to order of abundance, lazulite, rutile, cyanite, pyrophyllite, hydrous antho-

[1] Received July 18, 1921.

phyllite, hematite, quartz, and muscovite. In addition to these, Shepard[2] reported barite, minute perfectly formed transparent crystals of sulfur, crystals of pyrite, and traces of gold. The locality is probably best known for the occurrence of rutile, crystals of which have been figured and described by European crystallographers.

The ridge locally known as Graves Mountain has a length of 2 miles along an approximate northeast-southwest direction, is less than half a mile wide, and rises several hundred feet above the surface of the surrounding Piedmont Plain. The slopes of the ridge are very unequal, and are greatly roughened from weathering.

Graves Mountain is composed of Cambrian quartzite of which there are two facies:[3] (1) a foliated quartzite schist which forms the basal portion of the ridge and extends some distance up the slope on the northwest side, and (2) a fine-grained massive quartzite (itacolumite), which forms the crest and upper slopes. Both are composed dominantly of quartz with the difference in chemical composition shown in the following partial analyses:

	Quartzite schist	Massive quartzite (itacolumite)
SiO_2	79.18	69.74
Al_2O_3	14.14	24.86
Fe_2O_3	3.17	0.53

Igneous rocks are not known to occur in the ridge proper, but are common in the surrounding area.

Lazulite, a rare basic phosphate of aluminum, magnesium, and ferrous iron, corresponds to the formula (Fe, Mg) $(AlOH)_2(PO_4)_2$ in which the ratio of Fe:Mg(Ca) varies[4] from 1:12 to 2:3. It and the associated minerals occur in the itacolumite of the crest and higher slopes of Graves Mountain. The lazulite is irregularly distributed through the itacolumite in rude nests or bunches of single crystals and crystal aggregates. Quartz veins of a few inches thickness cut the quartzite on top of the ridge and sometimes carry rutile, pyrophyllite, and iron oxide, but lazulite has not been observed in them. The lazulite is imbedded in the itacolumite usually as crystals which range in size up to an inch in length, but as a rule the individual crystals are much smaller. It also occurs massive without distinct crystal boundaries. The crystals are usually acute pyramidal in

[2] C. U. SHEPARD. Amer. Journ. Sci. 27: 36–39. 1859.

[3] For a detailed description, including petrography, of the two facies of the quartzite, see THOMAS L. WATSON and J. WILBUR WATSON, *A contribution to the geology and mineralogy of Graves Mountain, Georgia*. Univ. of Virginia Publications, Bull. Philos. Soc., Sci. Sec., 1: 220–221 (No. 7). 1912.

[4] E. S. DANA. *A system of mineralogy*, pp. 798–799.

habit and frequently twinned. Shepard[5] described and figured five crystals of lazulite from the Georgia locality, and stated that a twin (his fig. 5) "is by far the most abundant form equalling in frequency all the others combined."

The mineral is opaque, of azure blue color when fresh, has uneven fracture, indistinct cleavage, and vitreous luster. Blow-pipe tests gave the usual reactions characteristic of the mineral. The lazulite is frequently intergrown with greenish to colorless columnar cyanite which is partly altered to muscovite (damourite), and is less often intergrown with coarse white quartz. Small grains of red rutile and of colorless quartz, especially the former, form frequent inclusions in the blue lazulite. The cyanite weathers yellow-brown in color and, like the lazulite, also contains inclusions of red rutile and colorless quartz. Similar red grains of rutile are also frequent in the quartzite. Weathered surfaces of the lazulite-bearing portions of the itacolumite are generally rough from the more resistant coarse lazulite and cyanite standing in relief. Scales of colorless mica are more or less conspicuous in weathered specimens of the rock.

When weathered, the lazulite is of lighter or paler blue color; sometimes almost entirely white or colorless, but is frequently spotted or mottled white and blue. Microscopically, thin sections show alteration of some of the lazulite along the periphery and fractures, into minute scales and fibers of a light gray nearly white substance, sometimes stained with iron oxide, having high refraction and double refraction, which probably can be referred to hydrargillite.

Under the microscope thin sections of the lazulite show inclusions of rutile and quartz, and occasionally cyanite and muscovite, all of which are common associates in hand specimens of the lazulite.

The lazulite is light blue in thin section and distinctly pleochroic, with $Z = Y > X$. It is optically negative (–), with 2V large.

The dispersion is slight, $\rho < V$. The values for the indices of refraction and the birefringence determined by Dr. E. S. Larsen on specimens of the lazulite yielding the analysis given below are as follows:

$\alpha = 1.604$, nearly colorless
$\beta = 1.633$, deep blue
$\gamma = 1.642$, deep blue
$\gamma - \alpha = 0.038$

A chemical analysis of the lazulite yielding the above optical data is given in table 1.

[5] C. U. SHEPARD. *Op. cit.*

The formula derived from the column of ratios in table 1 is that given in the standard texts for the mineral, except that CaO is usually not expressed:

$$(Fe, Mg\ (Ca))\ O.Al_2O_3.P_2O_5.H_2O$$

with FeO:Mg(Ca)O = 1:5, FeO:CaO = 1:1, and MgO:CaO = 4:1.

When compared with analyses of lazulite from other localities the Georgia mineral shows a high percentage of CaO (3.30 per cent), the largest reported in any analysis of the mineral of which the writer has found record. The analysis of lazulite from North Carolina quoted by Dana[6] shows no CaO. With two exceptions, Georgia and North Carolina, analyses of lazulite thus far published represent

TABLE 1. ANALYSIS OF LAZULITE

	I	II	III	
P_2O_5	38.25	40.61	286	1
Al_2O_3	33.92	36.02	353	1.2
FeO	3.99	4.24	59	
MgO	9.08	9.64	241	1.3
CaO	3.12	3.30	59	
H_2O	5.83	6.19	343	1.2
SiO_2	6.05			
	100.24	100.00		
Sp. G.	2.958			

I. Lazulite collected by Thomas L. Watson from Graves Mountain, Lincoln County, Georgia. J. Wilbur Watson, analyst.

II. Analysis I with the SiO_2, which represents admixed quartz, deducted, calculated to 100 per cent.

III. Ratios from II.

foreign localities, in which CaO is indicated as being either absent or present in quantity of less than 1 per cent. The only exception found by the writer is an analysis of lazulite quoted by Dana[7] from near the mouth of Churchill River, Keewatin, Canada, in which CaO is given as 2.83 per cent. Based on CaO content, published analyses of lazulite, most of which are old, would group the mineral under (*a*) calcium lazulite, apparently the less frequently occurring variety, to which the mineral from Graves Mountain, Georgia, and Keewatin, Canada, belongs; and (*b*) essentially calcium-free lazulite which includes the more common variety of the mineral represented by analyses from many European localities.

OTHER OCCURRENCES OF LAZULITE IN THE UNITED STATES.

Lazulite occurs both as crystals and as massive granular to compact material in quartz veins and in metamorphic rocks, especially quartz-

[6] E. S. DANA. *Op. cit.*, p. 799.

[7] E. S. DANA. *Op. cit.*, p. 799.

ites of the variety itacolumite. When fresh its azure blue color, vitreous luster, indistinct cleavage, and hardness (5–6) are the more important megascopic properties. It is subtranslucent to opaque, and has a specific gravity of 3 ±.

The known occurrences of lazulite in the United States are limited to North Carolina, South Carolina, and Georgia in the southeast Atlantic States,[8] and to California on the Pacific coast.

The localities are Graves Mountain, Lincoln County, Georgia; Chesterfield district, South Carolina; Clubb and Crowder Mountains, Gaston County, and Sauratown, Stokes County, North Carolina. The largest number of occurrences is in California, where the mineral has been reported from the following localities:[9] Breyfogle Canyon in Death Valley, Inyo County; San Gabriel Mountain, Los Angeles County; near Mono Lake and in Green Creek Canyon near Bodie, Mono County; and Oceanside, San Diego County. Foreign occurrences of lazulite have been reported from localities in Austria, Switzerland, Sweden, Brazil, and Canada.[10]

Probably the first occurrence of lazulite noted in the United States was by H. S. Hunter in 1822, near Crowder Mountain in the southern part of Lincoln (now Gaston) County, North Carolina. The mineral was found later in greater abundance near the southern end of Clubb Mountain, about 30 miles northeast of Crowder Mountain. Its occurrence in the North Carolina and Georgia localities is in Cambrian quartzite, as crystals and crystal aggregates irregularly distributed through the rock, usually in nests or bunches. With the exception of corundum, which is unknown in the Georgia locality, the mineral associates of lazulite in the two states are the same. They include rutile, cyanite, pyrophyllite, quartz, and damourite. The mineral association in the Chesterfield district, South Carolina, is, according to Genth,[11] pyrophyllite and cyanite.

Unlike the occurrences of lazulite in the Carolinas and Georgi a

[8] C. L. HUNTER. Amer. Journ. Sci. **15**: 376–377. 1853. J. L. SMITH and G. J. BRUSH. Amer. Journ. Sci. **16**: 370. 1853. C. U. SHEPARD. Am. Journ. Sci. **27**: 36–39. 1859. F. A. GENTH. Amer. Phil. Soc. **13**: 367, 382, 383, 404–405. 1873. E. S. DANA. *A system of mineralogy* (1900), p. 799. G. F. KUNZ. N. C. Geol. Survey Bull. **12**: 57. 1907. T. L. WATSON and J. W. WATSON. Univ. of Virginia. Publ. Bull. Phil Soc., Sci. Ser., 211–214 (No. 7). 1912.

[9] A. F. ROGERS. Sch. of Mines Quart. **33**: 375. 1912. D. B. STERRETT. U. S. Geol. Survey, Min. Res. for **1911**. Pt. II, p. 1060. A. S. EAKLE. Calif. State Mining Bureau, Bull. **67**: 162. 1914.

[10] For more details of foreign localities see E. S. DANA, *loc. cit.*

[11] F. A. GENTH. Amer. Journ. Sci. **18**: 410. 1854.

the mineral is found in quartz veins in some of the California localities, but its occurrence at Mono Lake in quartzite is similar to that in the southeast Atlantic states. Fewer minerals are associated with lazulite in the California localities, but those noted are also found in the southeast Atlantic states. In Green Lake Canyon,[12] near Bodie, lazulite is developed in deep blue anhedra associated with quartz and muscovite in a quartz vein; and in Breyfogle Canyon,[13] Death Valley, it is distributed as crystals and crystal aggregates of pale to fairly deep azure blue in patches through a white quartz vein cutting schist. At Mono Lake [14] it is associated with rutile in bands in a white quartzite.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

INORGANIC CHEMISTRY.—*The crystal structure of some carbonates of the calcite group.* RALPH W. G. WYCKOFF. Amer. Journ. Sci. **50**: 317–360. 1920.

By the same general method that has been employed in studying caesium dichloriodide and sodium nitrate, a unique solution has been obtained for the crystal structures of calcite and rhodochrosite. Of the assumptions commonly made in crystal-structure study, the only one required in this determination was that the atoms reflect X-rays in an amount roughly proportional to their atomic numbers. The structure of siderite was shown to be so nearly the same as that of rhodochrosite as to be indistinguishable by the means at hand. Magnesite was also found to give the same sort of pattern and hence to have the same general arrangement of atoms as the other members of the group.

The positions of the oxygen atoms, as determined by the present method and by the spectrometer results, are compared. In this particular case, the "normal" decline of intensities is in surprising agreement with the reflections. Evidence is obtained from these crystal structures to show the existence of groups of atoms, as carbonate groups, in the crystal. It is also pointed out that unless every atom in the crystal is electrostatically charged, the outside electrons of the atoms making up these crystals cannot be arranged at the corners of cubes.

Some connections are pointed out between the development of faces on calcite and its crystal structure, and a way is indicated of deciding the most probable indices of a plane when they are in doubt. The bearing of these structures upon the question of what constitutes a series of isomorphous substances is mentioned.

A criterion is suggested for determining, in the case of an hexagonal crystal, whether the fundamental unit is a rhombohedron or an hexagonal prism.

[12] A. F. ROGERS. *Op. cit.*, p. 375.

[13] D. B. STERRETT. *Op. cit.*, p. 1060.

[14] A. S. EAKLE. *Op. cit.*, p. 162.

The use of gnomonic projection in studying Laue photographs is mentioned and a ruler is described, the use of which reduces the time and labor of making such projections. The effect of the voltage impressed on the X-ray tube upon the character of the Laue photograph is considered and the best conditions for operating a tungsten tube for this work are stated. R. W. G. W.

PETROLOGY.—*The rhyolites of Lipari.* HENRY S. WASHINGTON. Amer. Journ. Sci. **50**: 446–462. 1920.

Typical obsidians, pumice, lithoidal rhyolite, and a hyalo-dacite of Lipari are described, with six new analyses. As these rhyolites are regarded as typical and have never before been completely analyzed, this work is of use in characterizing the type. The refractive indices of the obsidians and pumice are discussed. There is also given an analysis of an obsidian of the island of Milos, of which the refractive index was also determined. The data correspond well. This is compared with analyses of obsidian of Nisyros by Martelli. The observation is made that ferrous oxide dominates ferric oxide in the glassy forms of the same magma, while the converse is true of the crystalline forms in the Lipari rhyolites. The same holds good for the rhyolites of Sardinia and the pantellerites and basalts of Pantelleria, described some years ago by the writer. The possible relation of this to the magmatic gases in lavas is briefly discussed. H. S. W.

GEOLOGY.—*The potash deposits of Alsace.* H. S. GALE. U. S. Geol. Survey Bull. **715-B.** Pp. 39, pls. 2, figs. 2. 1920.

The discovery of potash in Alsace in 1904 broke the monopoly of the potash industry which since 1860 had rested with the producers in north-central Germany. The return of Alsace to France now divides the monopoly between two nations. The new field, although of less extent, is in some ways better than the older field; the beds are very regular, and the salts average remarkably high in potash. The deposits, which were discovered accidentally in boring, underlie an area of 65 square miles beneath the valley of the Rhine in southern Alsace. They consist of two regular beds of sylvinite, a simple mixture of potassium and sodium chlorides, included in dolomitic grayish shale of middle Oligocene age. The writer believes that the beds were deposited by evaporation in an inland salt-lake in the Rhine graben, which probably had no connection with the sea. Förste estimated the reserve of the field as 300,000,000 tons of pure potash, but by no means all of this can be recovered in mining. The crude salt mined in 1913 is reported as 350,341 tons, probably averaging 18 per cent in pure potash. J. D. SEARS.

GEOLOGY.—*A deposit of manganese ore in Wyoming.* EDWARD L. JONES, JR. U. S. Geol. Survey Bull. **715-C.** Pp. 3. 1920.

One of the few manganese deposits known in Wyoming is on the western flank of the Laramie Mountains, near the head of Sheep Creek. The core of the Laramie Mountains is a coarse-grained red granite of pre-Cambrian age, but flanking it on the west side is a series of sedimentary rocks ranging in age from Carboniferous to Cretaceous. The manganese deposit is interbedded in limestone and sandstone of the Casper formation, of Carboniferous age. The ore consists of the manganese oxides manganite and pyrolusite, in mammillary crusts and nodular aggregates, and is unusual for its number of crystals. It is contained in two beds of chert a few feet apart, from which it is thought to have been derived by weathering and leaching. J. D. SEARS.

GEOLOGY.—*Some deposits of manganese ore in Colorado.* EDWARD L. JONES, JR. U. S. Geol. Survey Bull. **715-D.** Pp. 12. 1920.

Many deposits of manganese ore in Colorado have been described by J. B. Umpleby in 1917 and the Colorado Geological Survey in 1918. A number of other localities were examined by the writer in 1917; these are located in Gunnison, Hinsdale, Ouray, Dolores, Custer, and LaPlata Counties.

Deposits of manganese ore in Colorado occur in sedimentary and igneous rocks ranging in age from pre-Cambrian to Tertiary. They are found in veins and brecciated zones; as replacement deposits; and as probably original bedded deposits. The veins and brecciated zones constitute by far the most numerous type of manganese deposits in Colorado, but economically they have proved of little importance. Replacement deposits of manganese ores occur principally in the oxidized parts of lead-silver deposits in the Leadville district, and of deposits containing zinc and iron sulfides in the Red Cliff district. A deposit of manganese ore which probably represents the oxidized and enriched part of an original sedimentary bed occurs in sandstone and shale in western San Miguel County. The manganese ores are composed dominantly of the oxides pyrolusite, manganite, psilomelane, and wad, generally mixed with iron oxides. J. D. SEARS.

GEOLOGY.—*Deposits of iron ore near Stanford, Montana.* L. G. WESTGATE. U. S. Geol. Survey Bull. **715-F.** Pp. 8, figs. 4. 1920.

The iron ores known as the Running Wolf hematite deposits lie just within the northern border of the Little Belt Mountains, in Cascade and Fergus Counties, Montana. A great series of sedimentary rocks, ranging in age from Algonkian to Cretaceous, rests unconformably upon Archean granite and gneiss. The deposits occur in tabular bodies in the Madison limestone (Carboniferous), at the contact with intrusive porphyry. The ore is a compact gray or reddish-gray hematite, which contains in places enough magnetite to make it react to the magnet; it is not to any large degree limonitic at the surface.

Development work has not gone far enough to make possible any estimate of the quantity of ore that can be mined, although several suggestive calculations are included in the paper. At the surface the ore body is of varying width, reaching a maximum of 50 feet. As it is a contact deposit in limestone, it will vary in dimensions from place to place according to the character and course of the solutions at work. The depth to which the ore extends below the surface is unknown. J. D. SEARS.

GEOLOGY.—*Phosphate rock near Maxville, Granite County, Montana.* J. T. PARDEE. U. S. Geol. Survey Bull. **715-J.** Pp. 5, pl. 1, fig. 1. 1921.

The phosphate bed and its inclosing rocks are bent into several parallel, tightly squeezed folds that trend northward. The westernmost fold, a large syncline, is partly overridden by a huge mass of rock brought by thrust faulting from the west, and the strata that form the western limb of the syncline appear as if overturned by a force acting from the west. East of the syncline and beyond the area of the overthrust mass all the anticlines lean to the west as if they had been pushed over by a force acting from the east. Presumably the thrust acting from the west was the later. On the south the folds are lost in areas of faulted and intrusive rocks, and on the north, owing to a persistent pitch in that direction, they disappear beneath a cover of later rocks. As a result of the structure and erosion combined, the out-

crop or surface trace of the phosphate bed forms a sinuous line that sweeps north and south, alternately bending sharply around the anticlines and synclines.

One hundred million tons of phosphate rock are estimated in reserve, of which a considerable part lies above the natural drainage channels in situations especially favorable for mining. J. T. P.

VOLCANOLOGY.—*The Katmai region, Alaska, and the great eruption of 1912.* CLARENCE N. FENNER. Journ. Geol. **28:** 569–606. 1920.

A preliminary account is presented of observations made by the writer as geologist of the expedition sent in 1919 by the National Geographic Society, in cooperation with the Geophysical Laboratory of the Carnegie Institution of Washington, to the Katmai region, Alaska.

The volcanoes of this region, which form a continuation of the Aleutian loop or festoon, are situated in an area of sedimentary rocks remarkable for the absence of folding or obvious faulting. The more recent lavas are basic andesites, contrasting greatly in composition with the highly siliceous rhyolite of the last eruption.

It is believed that in the fumarolic area of the Valley of Ten Thousand Smokes the injection of a sill or closely similar body of magma into the underlying strata at the beginning of the eruption caused shattering of the rocks above it, and these openings permitted the ascent of magma. The extrusion and inflation of this magma gave rise to a great ash-flow or sand-flow, analogous in many respects to the *nuées ardentes* of Pelée and La Soufriére, and also led to the formation of the parasitic cone of Novarupta. The fumaroles are thought to be due to the continued evolution of volatile constituents from this body of magma. The development of the new vent of Novarupta is ascribed to the enlargement of a channel along one of the fissures. The later extrusion of the stiff lava forming the dome of Novarupta is found to have been similar in many respects to that of the "spine" of Pelée.

A study was made to determine the manner in which the top of Mount Katmai disappeared and the great crater-pit was formed. It seems quite certain that the material was not blown out directly, but must be accounted for otherwise. Crater subsidence may have been a factor, but it is believed that collapse of the crater-walls and incorporation of the material in the new magma were chief features. It is recognized that the latter process demands a large quantity of heat for its accomplishment, and the magma evidently was not at very high temperature prior to extrusion; therefore accessions of heat seem to be demanded. A considerable problem is thus presented, but it does not seem at all insuperable, and it is believed that the evidences of solution are so strong that they cannot be disregarded.

One of the important features of the eruption brings up for consideration a phenomenon to whose significance little attention seems to have been paid hitherto. It is that of a gas-charged magma gradually developing the explosive condition after some interval has elapsed subsequent to its ascent from the depths. The Katmai magma seems to have followed this course, and the phenomenon is apparently not uncommon. This is believed to have great significance and to imply changes of physical environment during its ascent, effected with such rapidity that internal readjustments were not able to keep pace with them. C. N. F.

ENTOMOLOGY.—*The Dipterous genus* Dolichopus *Latreille in North America.* M. C. VAN DUZEE, F. R. COLE and J. M. ALDRICH. Proc. U. S. Nat. Mus., Bull. **116.** Pp. 304, pls. 16. 1921.

This paper is a revision of the North American species of the genus *Dolichopus.* It is divided into three parts. The introduction by J. M. Aldrich gives a historical account of the genus and notes on the habits of certain species. The second part, entitled "Classification," by M. G. Van Duzee, occupies the largest portion of the work. In it 219 North American species, many of which are new, are described, the location of the types is stated and there is an account of material before the author. This section is introduced with a synoptic table of the species. The males are treated first and are divided into nine groups. The females are also tabulated, but do not fall into the same groupings as do the males. This is due to the unusual and peculiar secondary sexual characters of the males. The third part is by F. R. Cole and consists of considerably more than 217 figures illustrating various characters of the species treated. Each species is assigned a number and when two or more figures are given for the same species they are given subletters of the species numbered.

This division of the paper in three parts makes it appear that the new species are to be accredited to Mr. M. C. Van Duzee and no statement to the contrary is definitely made, but in the introduction it is implied that new forms should be accredited to the three authors. The present writer understands that such is the intention of the authors of this important and comprehensive work. S. A. ROHWER.

ETHNOLOGY.—*The Owl sacred pack of the Fox Indians.* TRUMAN MICHELSON. Bur. Amer. Ethnology, Bull. **72.** Pp. 83, pls. 4.

The greater part of this bulletin consists of a text in the language of the Fox Indians and a translation of the same setting forth the ritual connected with it, its history, and the benefits supposed to follow upon the performance of the ceremonies. Some linguistic notes on the text are appended and a list of stems fills the 12 concluding pages. It contains contributions to the study of Indian linguistics, sociology, and religion. JOHN R. SWANTON

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

851ST MEETING

The 851st meeting of the Philosophical Society of Washington was held in the Assembly Hall of the Cosmos Club, May 7, 1921. It was called to order by President FARIS with 30 persons present.

The first paper, on *The self contained base range finder and its errors,* was presented by Mr. I. C. GARDNER (by invitation) and was illustrated.

The self-contained base range finder is probably the most interesting and highly developed optical instrument employed in warfare. The range is determined by triangulation with the base of the triangle actually contained within the instrument. It follows that the angle of parallax which is measured is extremely small and must be measured with great accuracy. For example, with a one-meter instrument at a range of 5000 meters the angle is approximately 40 seconds. The error of measurement for this angle must be less

than one second if an accuracy of 2 per cent in the determination of range is to be secured. To build an instrument which shall successfully attain this accuracy under service conditions and in the hands of men not thoroughly grounded in laboratory practice calls for the greatest refinement of optical and mechanical design.

The errors to which a range finder is subject are of two kinds. The adjustment error is a systematic error which is constant, when measured in angular units, for all settings of the instrument and may be considered as corresponding to a bodily shifting of the entire scale of the instrument with respect to the index. An adjustment is provided for correcting this error in the field.

The dispersion error is an accidental error arising from the inability of the observer to correctly determine precise coincidence in the field of the instrument. It may be either positive or negative and its distribution for a large number of observations may be expected to be in accordance with the ordinary frequency curve for errors. This error can be studied satisfactorily only by a laborious statistical method. A test has recently been completed at Fort Sill by the Ordnance Department with the cooperation of the Field Artillery and the Bureau of Standards which was represented by Mr. W. O. LYTLE. Approximately 21,000 separate readings of range were taken by a group of average observers with 17 different instruments on a selected series of targets. The most probable value of the dispersion error was found to be of the order of 0.9 second. Much greater differences were found in the dispersion errors of the different observers than in those of the different instruments. This indicates that at present the selection and training of observers offers a much better prospect for an immediate and spectacular increase in the accuracy of range finding than does the careful selection of an instrument from those types now available. For the poorer observers the dispersion error was approximately twice that of the better. In other words the poorer observer requires a two-meter base range finder in order to obtain an accuracy equal to that of the better observer with the one-meter instrument.

The paper was discussed by Messrs. HAWKESWORTH, WRIGHT, SOSMAN, HUMPHREYS, and FARIS.

The second paper, on *The spectral distribution of energy required to evoke the gray sensation*, was presented by Mr. IRWIN G. PRIEST and was illustrated.

The chief significance of this paper lies in the development and testing of an experimental method for determining an objective physical standard of "white light." The standard to be determined is the Planckian ("black body") distribution of energy required to evoke the hueless sensation of brilliance, commonly called "white" or "gray," under certain standard conditions stated in detail in the paper.

The method of producing and adjusting the spectral distribution of the stimulus is this: Light from a lamp of known spectral distribution is modified by rotary dispersion in a system of quartz plates and nicol prisms in such a way that by rotating one of the nicols the light emerging from it can be made to assume the spectral distribution of a Planckian radiator at any desired temperature between 4000° and 7000° K. Such a system is, in effect, a selective light filter of adjustable spectral transmission.

Two methods of observation were described: (1) The method of adjustment by trial, in which the observer himself adjusts the stimulus until he calls the sensation "white." (2) The method of answers, in which the operator conducting the experiment adjusts the stimulus to correspond to certain fixed temperatures of the hypothetical Planckian radiator; and records the

observer's reactions as "blue," "white," or "yellow," as the case may be. The second method proved to be the more satisfactory.

Experimental results were given from four observers. The average results of these observers indicate that "white light" may be represented: (1) theoretically, by the light from a Planckian radiator at a temperature of about 5200° absolute; (2) practically, to a fair approximation, by average noon sunlight at Washington. It is, however, emphasized that the final establishment of such a standard should be based on a more extensive statistical investigation.

The paper was discussed by Messrs. GARDNER, HAWKESWORTH, FARIS, BURGESS, TUCKERMAN, SOSMAN, and others.

The complete paper is being published as a Bureau of Standards Scientific Paper.

852D MEETING

The 852d meeting of the Philosophical Society of Washington was held in the Assembly Hall of the Cosmos Club, May 21, 1921. It was called to order by President FARIS with 36 persons present.

The first paper, on *Relation of coastal currents and winds on the Pacific Coast* was presented by Mr. H. A. MARMER and was illustrated.

This paper presented the results of an investigation of the speeds and directions of the current along the Pacific Coast of the United States brought about by local winds. The investigation was undertaken primarily for the purpose of aiding the mariner and was based on observations made under the direction of the Coast and Geodetic Survey by members of the crews of the five light vessels stationed along the coast from San Francisco Bay to the Strait of Juan de Fuca. The apparatus used for measuring the speed and direction of the current was necessarily the simplest, and consisted of a 15 foot current pole, a log line graduated to knots and tenths for a run of one minute, a stop watch, and a pelorus. The wind velocity was estimated in accordance with the Beaufort Scale.

Since the current as observed is the resultant of a number of different currents due to various causes, such as tides, winds, river discharge and differences in density, the observations are tabulated with reference to various arguments. Thus by tabulating with reference to time of tide at a nearby port for periods of 29 days, the tidal current is derived. This current on the Pacific Coast, offshore, is of the rotary type, the direction of rotation being clockwise, and shows considerable diurnal inequality. The wind current is derived by tabulating the observations with reference to winds of particular velocity and direction; then by summing for each such wind a large number of observations, the tidal-current may be considered as very nearly eliminated.

In the present investigation the observations were tabulated with reference to winds from a given direction divided in groups covering a range of wind velocity of 10 miles. The results derived show that on the Pacific Coast at a distance of from 4 to 10 miles from the land, winds from 10 to 70 miles per hour will give rise to currents from $^1/_4$ of a knot to over a knot; and this current will set, not in a direction of the wind, but in a direction of about 20° to the right of the wind. This has an important bearing on navigation, since winds blowing parallel to the coast or even away from the coast may give rise to currents tending to set a vessel on shore.

In the results presented for each of the light vessels the effect of fresh-water run-off at the light vessels stationed off San Francisco, Columbia River and

Swiftsure Bank was sufficiently large in some cases to change the direction of the current brought about by winds of moderate velocity from the characteristic deviation of 20 degrees to the right of the wind direction. But with increasing wind velocity the direction of the current approximated toward the direction of 20 degrees to the right of the wind.

This paper, which was illustrated by lantern slides, will form part of a Special Publication of the Coast and Geodetic Survey, dealing with currents on the Pacific Coast, to be published in the near future. It was discussed by Messrs. LITTLEHALES, FARIS, WHITE, WILLIAM BOWIE, and HUMPHREYS.

The second paper, on *New results concerning the diurnal variation of atmospheric electricity*, was presented by Mr. S. J. MAUCHLY, and was illustrated.

It has long been known that for any given locality the electrical potential difference between the ground and a point in the air, say 1 meter above ground (potential gradient), varies throughout the course of the day in an approximately cyclical manner; also that the amount and nature of this variation is not the same for all localities; that some localities have two maxima and two minima during a 24-hour cycle while others have only a single "wave." Although various authorities have assumed that the occurrence of the principal minimum about 4 p.m. was a rather general characteristic for nearly all stations, Mache and Schweidler[1] long ago pointed out that the phase angle of the 24-hour wave varied greatly from station to station while the phase angle of the 12-hour wave was approximately the same for nearly all the stations. The results of the observations made aboard the *Carnegie* since 1915, representing about half the Earth's surface, indicate that the average diurnal variation of the potential gradient at sea is of the single-wave type, *i.e.*, most days show only one maximum and minimum. However, a much more significant fact is the indication that the time of maximum, or of minimum, is approximately the same over all the different oceans, occurring on a *universal* rather than local-time basis.

Observations for the diurnal variation of the number of positive ions in the air, and also those for the variation of the electrical conductivity of the air due to its positive ions, indicate that in general both these quantities are, over all oceans, above average value during the day and below average value during the night. But in both cases the average range found was of the order of only 10 per cent of the respective mean values, while for the potential gradient the average range was between 30 and 40 per cent of the mean value. Thus it turns out, on the basis of the *Carnegie* diurnal-variation data now available, that the computed vertical current density due to positive ions (and probably the total current density) is also subject to a diurnal variation in which a single wave predominates, whose chief maximum (or minimum) occurs approximately at the same universal time over all the ocean areas.

Attention was directed to the fact that the diurnal-variation curves for the potential-gradient derived from the *Carnegie* observations are very similar to curves which represent the relative frequencies of the aurora borealis as observed at several stations and also to curves representing the diurnal distribution of magnetic disturbances when all are referred to the same time basis. It was pointed out that owing to the non-coincidence of the Earth's magnetic axis with its axis of rotation, the time of daily potential-gradient maximum, as indicated by the ocean curves, corresponds approximately to

[1] H. MACHE and E. v. SCHWEIDLER. *Die Atmosphärische Electrisität*, p. 27 (Braunschweig, 1909).

the time when the Earth's north magnetic pole, for example, is farthest from the sun. The actual times of maximum and minimum, however, appear to depend upon the positions of *both* magnetic poles and the fact that their longitude difference is not 180 degrees. These correlations support the assumptions of various investigators that the Earth's electric charge and resultant field may be very intimately related to an electric radiation from the Sun.

A more complete summary will appear in the current volume of *Terrestrial Magnetism and Atmospheric Electricity*. The paper was discussed by Messrs. C. A. BRIGGS, WHITE, and HUMPHREYS.

The third paper, on *New relations between terrestrial magnetism, terrestrial electricity, and solar activity* was presented by L. A. BAUER and was illustrated.

Connections between sun-spot activity, disturbances of the Earth's magnetism, earth-currents, and polar lights have been worked out by various investigators. The recent severe magnetic disturbances and earth-currents which accompanied a week ago the remarkable sunspot activity and brilliant display of polar lights have drawn renewed attention to the relationships between these four classes of natural phenomena.

The present paper shows that there is a fifth natural phenomenon—atmospheric electricity—with which an interesting and suggestive relationship with solar activity is exhibited. Owing to the many disturbances to which the atmospheric-electric elements are subject, as for example during cloudy and rainy weather, it has been difficult to establish the existence of definite variations of the chief atmospheric-electric elements during the well-known sun-spot cycle of somewhat over 11 years than in the case of magnetic effects, earth currents, and polar lights. The new results found are based upon atmospheric electric data obtained chiefly at four European observatories between 1898 and 1919, the combined data, in the case of the potential gradient, thus covering about two sun-spot cycles. Recent observations on board the *Carnegie* indicate a decrease in the electric potential-gradient since 1917, when sun-spot activity was at a maximum.

The following chief facts have resulted:

(1) The Earth's average intensity of magnetism, as well as the strength of the normal electric currents circulating in the Earth's crust, suffers a diminution during increased solar activity, *i.e.*, the currents induced in the Earth during periods of increased solar activity are in general reversed in direction to the normal currents, the strength of these superposed currents increasing with increased solar activity. The diurnal range of the strength of the normal earth currents, as in the case of the diurnal range of the Earth's magnetic elements, increases with increased sun-spot activity.

(2) The atmospheric potential gradient, or the deduced negative charge on the surface of the Earth, increases with increased solar activity, the range in the variation between minimum and maximum sun-spot activity being about 20 per cent. The electric conductivity of the atmosphere, on the other hand, shows but little, if any, systematic variation during the sun-spot cycle. Accordingly, since the vertical conduction current of atmospheric electricity is derived from the product of the potential-gradient and the electric conductivity, it is found that this vertical current increases in strength with increased solar activity. It would thus appear that atmospheric electricity, like terrestrial magnetism, is controlled by cosmic factors. The results derived here may have an important bearing upon theories of atmospheric electricity.

(3) Instead of using for short periods, as for example a month, the sun-

spot numbers direct for comparison with magnetic and electric variations, it is found that a more satisfactory measure of solar radiations and emanations affecting the Earth's magnetic and electric condition may be based upon the monthly range of sun-spot frequency, or upon some quantity indicative of the rate of change, or variability of sun-spottedness.

(4) A discussion of the sun-spot data for the period of 44 years, 1876–1920, confirms the existence of an annual periodicity in sun-spottedness, the minimum occurring about the time (January) when the Earth is nearest the Sun, and the maximum occuring on the average in July, when the Earth is farthest away from the Sun; the average difference between maximum and mimimum is about 6 sun-spot numbers. There would thus be given additional support to the view of planetary influence upon sun-spottedness.

(5) The electric potential-gradient, on the average, for both hemispheres shows a minimum value in July and a maximum in January; the annual range is about 50 per cent. On the other hand, the Earth's magnetic energy, as well as the strength of earth-currents, show on the average a higher value during the summer months than during the winter months for the northern hemisphere.

The paper was discussed by Dr. HUMPHREYS.

A more complete summary will appear in the current volume of *Terrestrial Magnetism and Atmospheric Electricity.*

H. H. KIMBALL, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Mr. LOUIS V. DIETER has resigned as bacteriologist of the Health Department of the District of Columbia. He had been with the department since 1909.

Dr. HENRY GORDON GALE, professor of physics at the University of Chicago, has been made chairman of the Division of Physical Sciences of the National Research Council, for the year ending June 30, 1922.

Captain ANTHONY FRANCIS LUCAS, retired mining engineer, died at his home at 2300 Wyoming Avenue on September 2, 1921, in his sixty-sixth year. Captain Lucas was of Montenegrin origin and was born at Trieste on September 9, 1855. He was for a number of years an officer in the Austrian navy. He took an active part in the development of the oil and gas fields of the Gulf Coastal Plain, and was particularly interested in the geological problems of the origin of petroleum and the origin of the salt domes of Louisiana and Texas. He was a member of the Geological Society and the Society of Engineers.

Mr. J. E. NOBLE has been appointed bacteriologist of the Health Department of the District of Columbia.

Dr. GEORGE B. ROTH, pharmacologist with the Hygienic Laboratory of the U. S. Public Health Service, resigned in September to accept a teaching and research professorship at Western Reserve University, Cleveland, Ohio.

Mr. CHARLES K. WEAD, for over twenty years an examiner in the U. S. Patent Office in the Class of Music, has resigned, and will reside at Ann Arbor, Michigan.

Professor CHARLES E. WEAVER, non-resident member of the ACADEMY, has returned to the University of Washington at Seattle to resume his work as professor of paleontology, after a leave of absence of three years in Central and South America as geologist for the Standard Oil Company.